# An assessment of the use of satellite remote sensing for the quantitative mapping of the forest biomass. A case study: the project LEBEN-Abruzzo

Lucien Wald

# AN ASSESSMENT OF THE POTENTIALITY OF SATELLITE REMOTE SENSING OF BIOMASS FORESTRY. CASE STUDY : THE PROJECT LEBEN-ABRUZZO.

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Head of project : Dr. L. Wald, Ecole Nationale Supérieure des Mines de Paris

Contractor : Armines

Address : 60, bd Saint-Michel
F - 75272 Paris cedex 06

Summary

The goals of the project are primarily the determination of the methods allowing the mapping of the forestry biomass from satellite imagery and secondly the mapping of the areas of accumulation of energetic resources as a function of physical, geographic, social and economic factors. The area under study is the province of Abruzzo in Italy and this project is part of the greater project LEBEN-Abruzzo. The satellite data used are from the Thematic Mapper and the MultiSpectral Scanner both aboard Landsat-5. These data are compared to the maps of biomass and we are making use of the fine resolution at ground of these data to improve the existing maps. These improved maps entered a data base together with other maps (topography, roads, administration, etc...). Further these data are combined according to various criteria to give a synthetic map of the accumulation of the energetic resources or to simulate a net of forest roads or sites of localisation of a fire-prevention system.

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## 1. INTRODUCTION

The search for renewable energies demonstrates that the extraction of energy from the biomass of the forests is a realistic concept. However accurate mapping of the distribution of the biomass does not exist on large scale. This project intends to fill up this lag and to use the fine resolution obtained by the Earth observation satellites to improve the existing maps of biomass in the province of Abruzzo, in Italy.

To our knowledge, no similar work was ever done till now. A lot of studies have make use of what is called "vegetation index". This index is certainly related to the biomass but no quantitative relation has been ever computed. The first goal of this project is to find such a relation.

The second and last goal is to design and realize a computerized database for an optimal management of the energetic resources. Such databases are not common. Only 10 out of the 53 States of the USA created a numeric database for the management of the forests. These databases are mainly used for forest inventories and they are making use of satellite imagery only in case of disaster. Cartographic synthesis are commonly executed but none of these databases is linked to a system-expert or to a computer-aided system of decision including modelling of some factors.

## 2. ASSESMENT OF THE BIOMASS FROM SATELLITE IMAGERY

The inventories made from ground generally offer accurate estimations of the biomass over areas greater than 1 km2. It is attractive to use the fine resolution of some satellites observing the Earth to improve the knowledge of the distribution of the biomass up to 100 m2. The satellites under concern are SPOT (resolution : 20 and 10 m) and Landsat and its two sensors : Thematic Mapper (resolution : 30 m) and MultiSpectral Scanner (resolution : 80 m).

The only data used in this project come from the Landsat-5 satellite because the SPOT satellite was not operational at the time of the inventory made at ground in the Abruzzo. The satellite data are first sectorized and then are navigated with an extreme accuracy better than half a pixel, so that the satellite image is perfectly superposed to the existing maps.

Once this pre-processing done, a factorial analysis of the satellite data set versus ground data will be made. The ground data set includes the species of the trees, the height of the forests and the volume of wood. The satellite data set is composed either of TM seven spectral bands and of combination of these bands, or of MSS four bands and combinations. This multiple parameters correlation will be applied to a few samples (training areas) and the results will be extended to the whole area covered by the satellite image. The comparison of the satellite estimation and of the actual measurements will determine the accuracy of the assessment of the volume of wood from satellite data. Then

the resolution of the satellite sensor (30 or 80 m) will refine the existing maps of the species, of the height of the trees and of the volume of wood.

Although the MSS sensor is less accurate both in space and in spectral bands than TM, its data and their processing are far less expensive than TM images. Also of importance is the existence of archives of MSS data covering the whole Earth. Our intention is to compare results from both satellite data sets and determine the degree of accuracy which can be obtained for minimal costs.

## 3. THE DATABASE

Entering a map into the database implies first a digitalization of the map and secondly a geometric transformation of the map to fit the reference cartographic projection of the database. The data entering the database may be of various types. The first type is "surface" (polygons) as encountered in mapping the biomass or the administrative zones. The second type is "line" used to map the roads or the electrical wires. The third type is "point" for water tanks or masts. The last type is "texte" like rules and laws.

The database covers the province of Abruzzo and has the size of a rectangle of 136.6 km N-S and 152.8 km E-W. The pixel size is 100 m. Presently three maps were communicated to us by ERSA-Abruzzo and entered the database by the mean of a digitalizing table. These maps deal with administrative limits and height of the trees. Other data (relative surface for each species, volume of wood, growth rate, surface of forest owned by individuals) were given as numbers on paper sheets and were transformed in maps entering the database. Next the topographic maps, the roads net and the biomass map derived from the satellite data will enter the database.

## 4. MAP SYNTHESIS

The data will be combined in different fashions to obtain synthetic maps in view of a computer-aided management of the energetic resources. In particular, the biomass will be mapped as a function of the distance of the energetic areas to the existing roads and as a function of the topography. This may be considered as an index of exploitation easiness which will be related to exploitation costs. It is also intended to suggest a net of forest roads minimizing the distance to the cut areas and the transport costs and also to suggest localizations of a system for fire-prevention for a better protection of the energetic resources.

## 5. HARDWARE AND SOFTWARE

The satellite data were provided on magnetic tapes. These tapes were read by a Bull SPS-9 and then sectorized data were transferred towards a micro-computer IBM-PC like. Any further processing of the satellite data, the

geometrical transformations, the digitalization of paper maps, the factorial analysis, the production of synthetic maps and so on are entirely executed with this micro-computer using the software package CARTO-PC designed and realized by CTAMN-Armines. The database is registered on a numerical optical disk coupled to the micro-computer and is also entirely managed by CARTO-PC.

## 6. CONCLUSION

Presently no definite conclusion was reached. The study is still in progress. This project deals with two innovations : the assessment of the resources from satellite and the link of this assessment with a geocoded database for a computer-aided management of the energetic resources.

Assessing biomass from satellite will allow a regular update of the maps of the available energy at low cost.

The geocoded database and the link between it and the satellite data is a real improvement for management, allowing a quick answer to any change in environment. Further the computer-aided management system will evolve towards a system-expert in management where rules of any kind (social, economics, politics, natural environment, geology, geography, meteorology, ...) and under any forms (map, text, confuse knowledge, ...) will be introduced in the database and in the base of laws. Management simulations will be possible with this system-expert and the results of these various simulations will help for an optimal management of the energetic resources.